PHOTO-ELASTIC METHOD OF STRESS ANALYSIS FOR PANEL OF INFILL FRAME SUBJECTED TO RACKING

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ABSTRACT: A two dimensional photo-elastic model analysis has been adopted to analyze the masonry infill behavior in an in-filled frame against racking load. The stress distribution is studied for the relative stiffness of the frame and infill, equal to 3.5.The model tested is composite, fabricated using Aluminum for frame and araldite AY103 with hardener HY 951 as the infill material. Observations of the model placed in the photo –elastic bench revealed the visible picture of fringes over the whole area of the infill from which the stress distribution is accurately readable at any point for both the direction and magnitude. The results illustrate that the photo-elastic method can be effectively utilized to study the elastic behavior of in-filled frames.
KEY WORDS: In-filled frames, failure modes, masonry panel, relative stiffness, epoxy resins, photo-elastic bench.

1. Introduction:

Analysis of in-filled frames for stresses has been arrived at by various analytical and experimental methods as documented in the published work. It has been established that the analysis of in-filled frame is a complicated one as it involves structural interaction and stress concentration. The mutual interaction of the frame and in-fill plays an important role in controlling the stiffness and strength of the in-filled frame and the problem is to be examined in terms of their relative properties. The relative property of in-fill and frame is controlled by the parameter λh, smaller the value of λh, stiffer the frame relative to the infill. In the present analysis the value of λh has been chosen to be 3.5.
As both structural interaction and stress concentration are involved, obviously experimental stress analysis was envisaged and photo-elastic method has been employed to study the complete stress distribution in the in-fill.

2. Methodology:

2.1 In-filled frame model:
Epoxy resin was chosen as one model material of the in-fill because of various advantages like ease with which it can be casted, optical sensitivity etc. Araldite AY-103 and harder HY-951 were used to cast an in-fill model of size 58×58×6 mm. For the frame aluminum plate of 6 mm thickness had to be machined to represent structural members to detailing. To relieve the stresses induced during cutting and machining, liquid paraffin bath technique has been adopted.
Calibration of the photo-elastic material i.e. the in-fill was carried out using a tension specimen. Young's modulus of the model material has been arrived at by loading at two points on a small strip of araldite specimen.

2.2 Testing arrangement of lateral load:
The models were made in a duplicate back to back arrangement to simulate rigid foundation for each half, and to allow for ease of testing. The testing arrangement for the model analysis is shown in Fig .1a and Fig. 1b

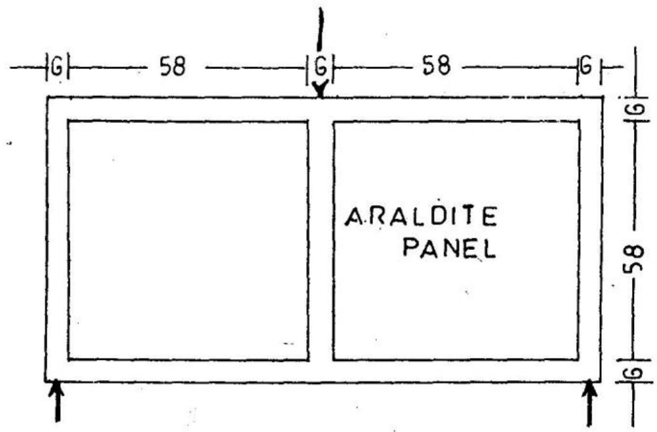

Fig.1a Testing arrangement (Dimension in mm)

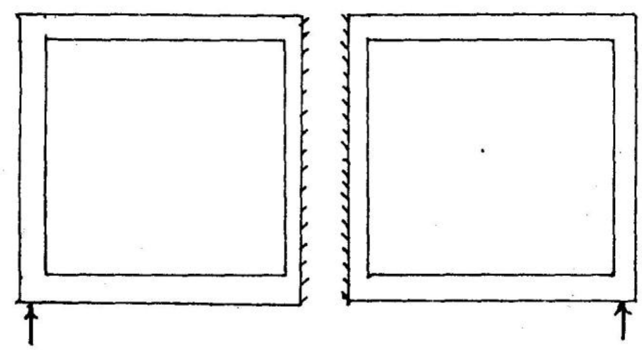

Fig. 1b Equivalent effect of testing arrangement

2.3 The parameter λh for the model:

The behavior of in-filled frames has been shown by Stafford smith to be partly related to the flexural stiffness of the frame relative to the in-plane diagonal of the in-fill defined by the parameter λh where

$$\lambda h = \sqrt[4]{\frac{E_1 t h^3}{4EI}}$$

In which, E_1, t and h are the modulus of elasticity, thickness and height of the in-fill frame respectively and E and I are the modulus of elasticity and second moment of area of the columns respectively. A ratio of E and E_1 considered to be a representative ratio of reinforced concrete frame with a masonry in-fill works out to be 18 for E_1 to be 4200MPa and E to be 75000MPa and for infill thickness of 6mm with a height of 58mm, and for a width of the frame 6mm and thickness of 6mm, λ h will be 3.5.

2.4 Measurements

For the measurements of magnitude and direction of principal stress a plane polarioscope is used with white light and with necessary calculations, various stresses are obtained and are discussed below.

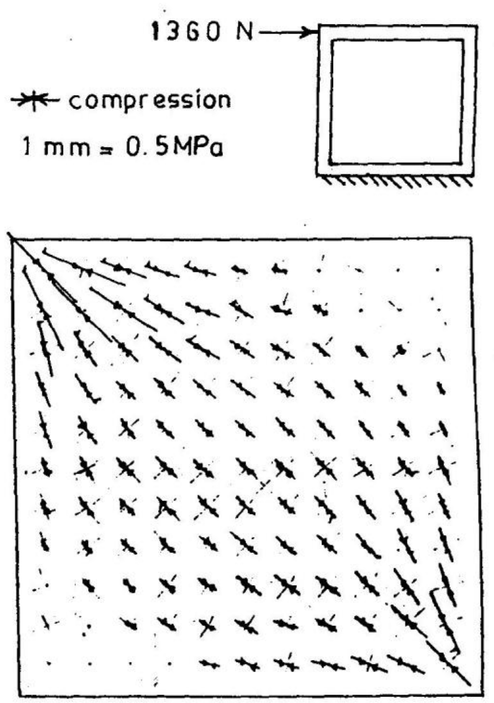

Fig 2 Flow of stresses in the panel of solid in-filled frame.

3. Analysis of result:

3.1 Principal stress distribution

Flow pattern of principal stresses in the infill for solid infill is shown in fig.2. The length of contact will be only over a small length at the loaded corners and as such the compressive stress concentration gets localized. Most of the tensile stresses at the corners of the tensile diagonal of the infill get relieved.

3.2 principal compressive stress contours

To study the gradient of compressive principal stress distribution in the infill panel, compressive stress contours are drawn and presented in fig.3 which shows that the contours are concentrated at the corners of the in-fill along the loaded diagonal and also most of the region of the infill panel is stressed by compressive stresses.

3.3 principal tensile stress contours

The principal tensile stress contours, revealed that the tensile stress contours run along the loaded diagonal and hence is susceptible for initiation of tensile cracking as the masonry is very weak in tension.

3.4 Vertical stress distribution

Fig.4 represents the vertical stress distribution in the infill panel. The stress concentration at the infill corners loaded increase substantially. At the base of the infill, the compressive stress gets concentrated over a small length of contact and similarly at the top edge also. Because of high stress concentration the failure of the infill initiates crushing at the infill corner.

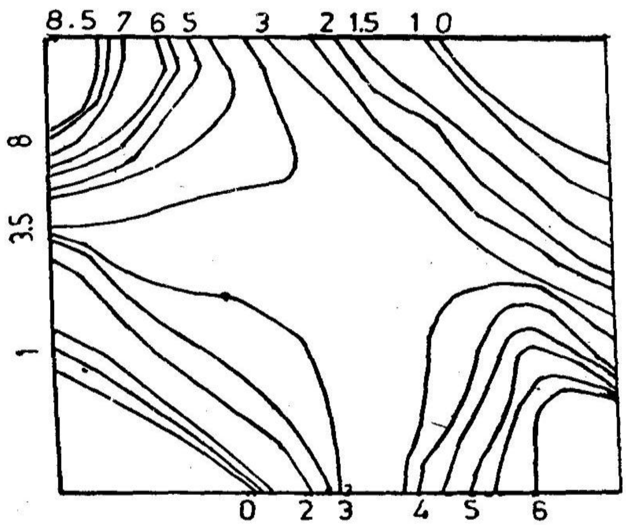

Fig 3 Principal compressive stress contours in the infill (stresses in MPa)

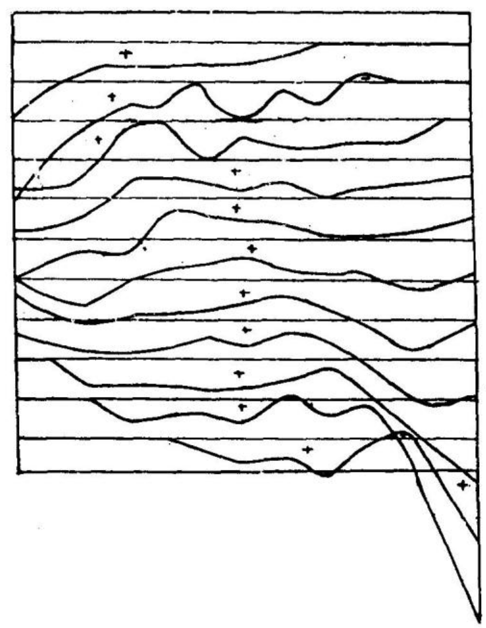

Fig 4 Vertical stress variation across the panel (1mm=0.12MPa)

3.5 Horizontal stress distributions

At the loaded points compressive stress concentration observed is more along the two vertical edges where there is no contact with the frame horizontal stresses are found to be zero.(fig.5)

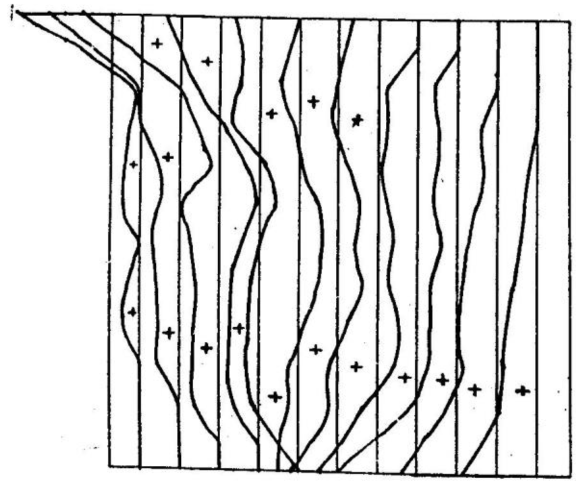

Fig 5 Horizontal stress variation across the panel (1mm=0.12MPa)

3.6 Shear stress distribution

The shear stress distribution shown in fig.6 depicts shear stress concentration at the corners of the support and the load. At top and bottom of the infill it is not uniform but varying in nature, the mid portion of the panel behaves as a rectangular beam. Along the vertical edges of the infill wherever separation takes place shear stress is zero.

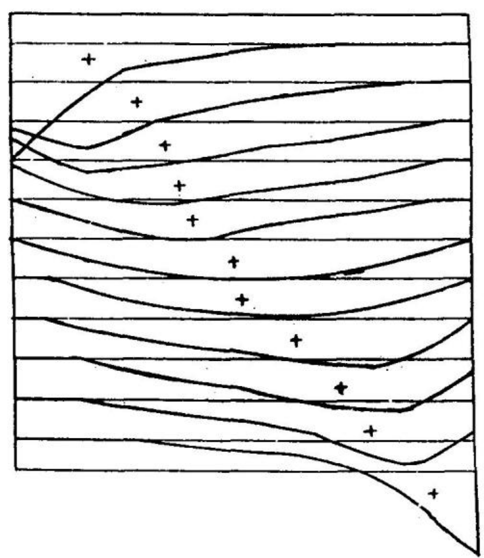

Fig 6 Shear stress variation across the panel (1mm=0.12MPa)

4. Conclusions

1. The photo-elastic method of analysis using transmission polariscope can be effectively used to study the elastic behavior of in-filled frames.

2. Full interaction at the panel frame interface contributes to the composite nature of the structure and the strength and also the establishment of full interaction at the interface.

3. When horizontal load is applied, the frame racks and bears against the infill panels across their loading diagonals, causing them to behave as diagonal compressive struts. As the horizontal loading is increased, the infill is liable to one or more of three modes of failure. The first possibility is a diagonal tension crack along the compression diagonal. This is induced by the outward curving components of the compressive stress trajectories from the infill compression diagonal. The second, a shear failure, follows an approximately diagonal path. The third is a crushing of a corner of the infill, at one end of the diagonal strut, where compressive stress concentration is very high.

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